LOW TEMPERATURE EVALUATION OF THE UCC3585 LOW VOLTAGE SYNCHRONOUS BUCK CONTROLLER

Test Report

Scott Gerber
ZIN Technologies
&
Ahmad Hammoud
QSS Group, Inc.

NASA Glenn Research Center
Cleveland, Ohio

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Background

The Texas Instrument/Unitrode UCC3585 is a BiCMOS synchronous buck controller chip for low voltage applications[1]. It has a fixed frequency oscillator and a complementary pair of power MOSFET transistors. This device was identified and selected for evaluation for potential use in the development of a low temperature dc-dc converter module. The performance of the BiCMOS-structure devices at low temperature is questionable. Typically, CMOS devices perform relatively well down to approximately liquid nitrogen temperature (-196 °C). Bipolar devices, on the other hand, are known to suffer performance degradation at low temperature. BiCMOS devices are a hybrid of these two families and as such may or may not perform well at low temperatures.

Test Setup

A circuit board, populated with the UCC3585 chip and few passive components, was designed and built for evaluation in the temperature range of +25 °C to -190 °C. Performance characterization included switching frequency, duty cycle, and dead-time. The UCC3585 synchronous buck controller was tested under the following conditions:

- Oscillator frequency set to approximately 110kHz
- Duty cycle controlled via external voltage applied to COMP pin

This configuration yielded a duty cycle control in the range of 0 to 100% at both the P channel and N channel drive outputs of the controller.

Results and Discussion

Testing of the device was initially performed at 25C after which measurements were taken at lower temperatures with an increment of 25C. At each test temperature, the device was allowed to soak for 15 minutes before measurements were made. The performance of the device as a function of temperature is depicted in Table I. Listed are the test temperatures, the switching frequency, and the dead-times (t1 and t2) of the driver outputs that are providing switching for the P- and N-channel MOSFET transistors. It can be clearly seen in Table I that the switching frequency decreases slightly with decreasing temperature. In addition, significant decrease in both dead-times occurs as test temperature was decreased. At -115 C, for example, the switching frequency decreased by about 11%. At this temperature, dead-time t1 decreased by about 38% from its room temperature value; while dead-time t2 was reduced by about 21%. Although the device exhibited these changes with temperature, it has, nonetheless, maintained good operation in the temperature range between +25C to -115C. A slight variation seems to occur in the duty cycle control as temperature approaches -115C. This however can be compensated by slight adjustment of the voltage feeding the COMP input.

At temperatures beyond -115C the device begins to exhibit fluctuations in duty cycle control. This instability became more severe as temperature was decreased further, and the control was completely lost when the temperature reached -150C. The device seemed to regain normal operation when the temperature was raised above -115C. The waveforms of both the P- and N- channel drive outputs are shown in Figure 1 at test temperatures of +25C and -100C. The spikes appearing at the switching

transients of the waveforms are attributed to circuit layout and long lead wires that were used between the device inside the environmental chamber and the benchtop instrumentation. The dead-times associated with the transistor driver outputs are shown in Figure 2. These dead-times are defined as the transition period between the 50% values of the rise and fall times (and vice versa) of the P- and N-channel transistor drivers.

Conclusion

The UCC3585 synchronous buck controller, which is a commercial-grade rated for 0 to 70 °C operation, has been evaluated for potential use in low temperature applications. The results from this preliminary work indicate that the device is capable of low temperature operation in the range of +25C to -115C. For temperatures below this range the device showed unstable operation and complete loss in control. Further comprehensive testing is required for a complete assessment of the performance and stability of the device under long term temperature conditions. Military-grade devices that are rated in operation temperature from -55 °C to 125 °C need also to be investigated.

References

1. UCC3585 Low Voltage Synchronous Buck Controller Data Sheet, Texas Instruments, Inc.

Acknowledgments

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Table I. Summary of low temperature testing of the UCC3585.

Temperature (°C)	**Frequency** (kHz)	**t1** (ns) N P OFF → ON	**t2** (ns) P N OFF → ON	**Performance**
25	110	90	224	normal operation
0	109	84	218	normal operation
-25	107	78	212	normal operation
-50	106	68	202	normal operation
-75	103	66	194	normal operation
-100	100	56	188	normal operation
-115	98	56	176	normal operation
-125	98	48	168	unstable - reduced control
-150	--	--	--	no control

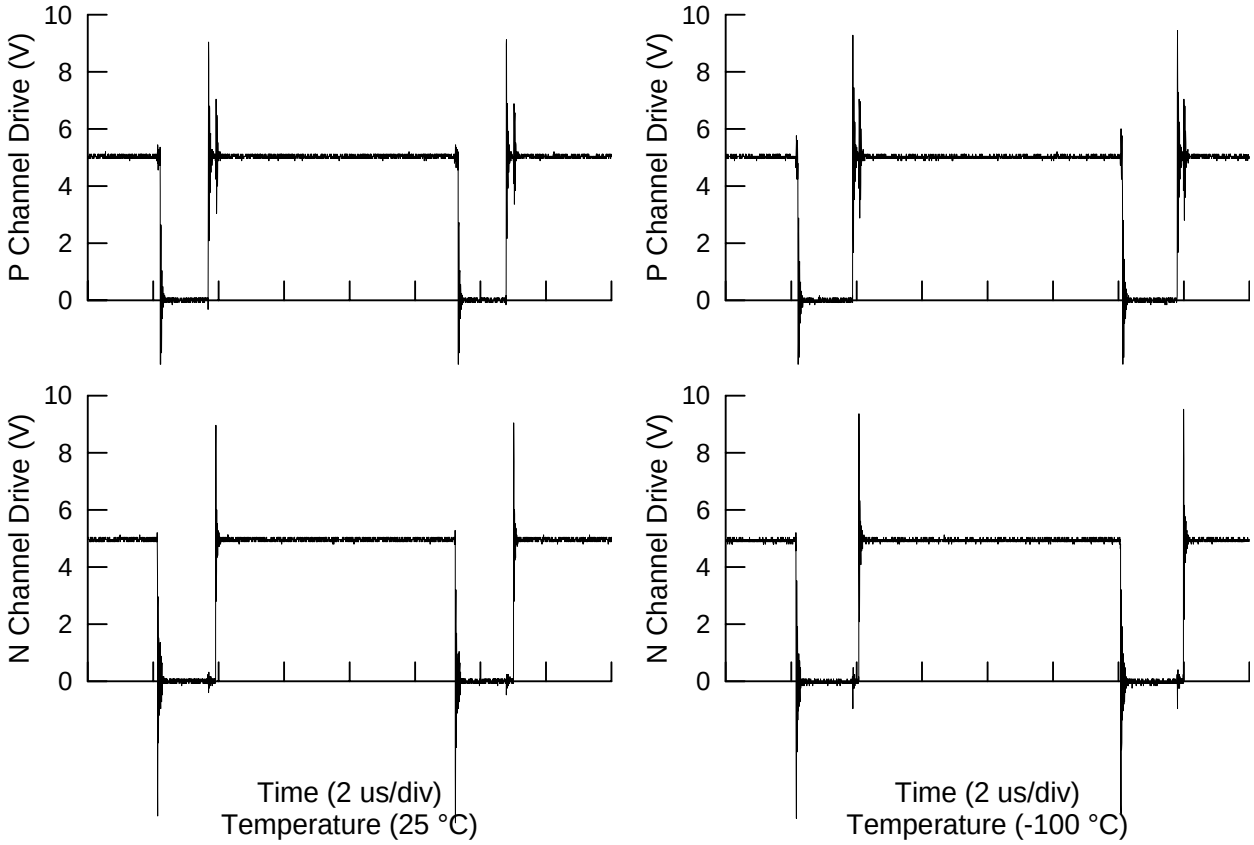

Figure 1. P and N channel drive outputs for the UCC3585 (referenced to ground) at 25°C and -100°C.

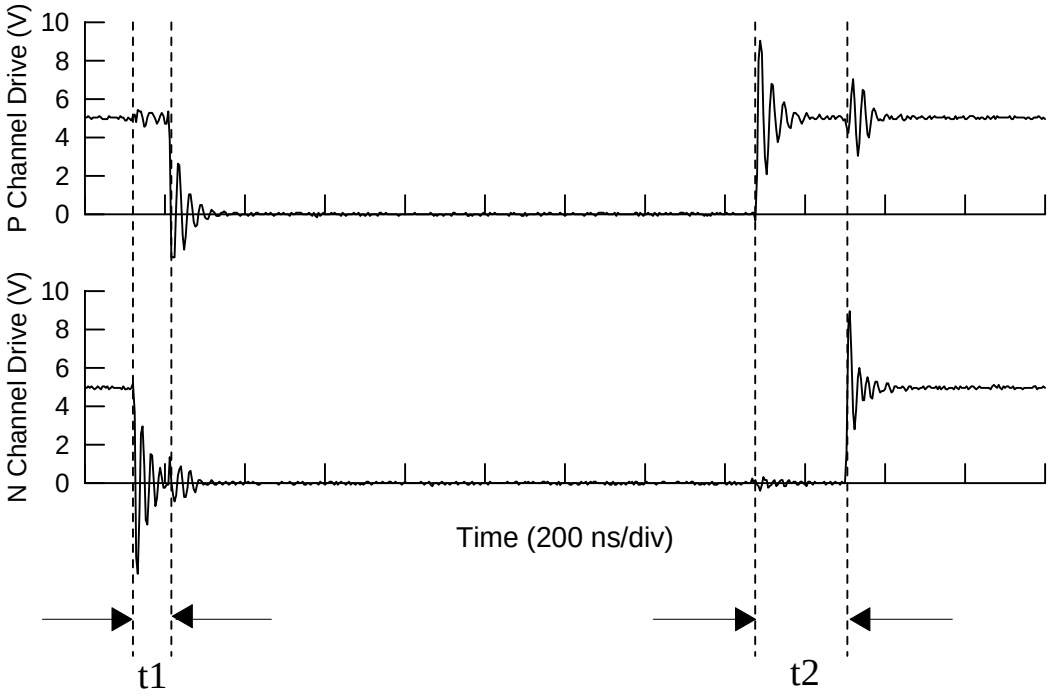

Figure 2. Dead-time for UCC3585 at room temperature